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AUTHOR Mock, Karen R.; And Others
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ABSTRACT

This study investigated whether the stimulant methylphenidate (Ritalin) would differentially affect performance on a test of cognitive style by hyperactive children. Subjects were 55 children, (ages 7 to 15) referred to the Learning Clinic at the Hospital for Sick Children, Toronto, Canada for hyperactivity and/or learning problems. A paired associate learning task was used to classify subjects as favorable or adverse responders to stimulant medication. Favorable responders included two distinct clinical groups: those described by teachers and parents as aggressive, impulsive, and acting out, and those referred for daydreaming, distractibility, and problems in maintaining attention. All subjects were given Kagan's Matching Familiar Figures (MFF) test, a test of reflective/impulsive cognitive style. It was found that stimulant medication (Ritalin) resulted in poorer MFF performance for adverse responders but improved performance for the impulsive and distractible groups. Results suggest that stimulants affect cognitive style differentially depending on the child's clinical/behavioral profile. (Author/SE)

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# STIMULANT EFFECT ON MATCHING FAMILIAR FIGURES: CHANGES IN IMPULSIVE AND DISTRACTIBLE COGNITIVE STYLES

KAREN R. MOCK

University of Toronto, Faculty of Education

JAMES M. SWANSON AND MARCEL KINSBOURNE

Hospital for Sick Children, Neuropsychology Research Unit

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ABSTRACT

Fifty-five children referred to the Learning Clinic with symptoms of hyperactivity were given the MFF task after taking methylphenidate (Ritalin) and after a placebo, under double-blind conditions. Subjects were objectively classified as favorable or adverse responders to stimulant medication. The former presented as two distinct clinical groups: those described by teachers and parents as aggressive, impulsive, and acting out, and those referred as daydreamers, distractible, with problems in maintaining attention. It was found that stimulant medication resulted in poorer MFF performance for adverse responders but improved performance for the impulsive and distractible groups. Results suggest that stimulants affect cognitive style differentially depending on the child's clinical/behavioral profile. Educational implications are discussed.

Stimulant Effect on Matching Familiar Figures:
Changes in Impulsive and Distractible C ognitive Styles

Karen R. Mock, James M. Swanson, Marcel Kinsbourne

Individuals differ with respect to the speed with which they make their decisions, and the instrument most often used to measure this cognitive tempo or cognitive style is the Matching Familiar Figures Test (MFF), developed by Kagan et al (1964). The test format involves simultaneous presentation of a familiar figure with several facsimilies differing in one or more details, creating a situation of high uncertainty when the subject is asked to select from the alternatives the one that exactly matches the standard. When a person undertakes to solve a problem containing some uncertainty, he must engage in a search for information; that is, he must delay decision-making in order to evaluate alternative hypotheses.

Faced with response uncertainty, if a person responds quickly before obtaining sufficient information, he is likely to be incorrect. Such a response style (short decision time, high error rate) is described as impulsive (Kagan, 1965) and is a maladaptive style for most problem solving. A cognitive style characterized by longer decision time and fewer errors Kagan called reflective, a style which represents an optimal response strategy if the individual delays just long enough to obtain sufficient information for an accurate decision. Cognitive tempo, then, may be described in terms of a speed/accuracy tradeoff, and reflectivity (or impulsivity) may be used to label the disposition of an individual to delay (or not to delay) before responding when faced with uncertainty.

Differences in cognitive style have been suggested as the core factors which account for most of the behavior and performance deficits of children described as hyperactive (Campbell, 1971; Douglas, 1972, Kinsbourne, 1973). Commonly accepted symptoms of the hyperactive syndrome such as excess activity level, emotional lability, intractibility to discipline, school learning problems, short attention span, distractibility, etc. (Wender, 1971) may reflect problems in attention and impulse control rather than differences in cognitive skill or intellectual ability (Campbell, 1971). Stimulant medication has been shown to improve the hyperactive child's attention to various tasks and/or to increase arousal level, thereby enhancing performance (Connors, Eisenberg, and Barcai, 1967). However, the few studies examining the cognitive style of hyperactive children using the MFF task have yielded equivocal results.

Children diagnosed as hyperactive have been found generally to be more impulsive on the MFF than normals. Campbell (1973) reported that the MFF scores of children assessed as hyperactive in an outpatient psychiatric clinic indicated more impulsivity than those of normal reflectives and comparable to the scores of normal impulsives. Juliano (1974) has also found a greater ratio of impulsives to reflectives among hyperactives than among normal children; but in that study, the MFF latency-error correlation was atypically low (-.37), and the pattern of correlations favored MFF errors and not response time as the useful predictor. Campbell et al (1971) reported that when methylphenidate was administered, the impulsivity of hyperactive children decreased; that is, error scores decreased and response latency increased.

When evaluating MFF performance, the child who is above the median on response time and below the median on errors is considered reflective, while the child who is below the median on response time and above the median on errors is called impulsive. However, the median split on the negatively correlated measures of response time and errors actually defines a 2 x 2 matrix: the reflective subjects and impulsive subjects are those who fall in the two diagonally-located cells, leaving the rest in the counter-diagonal cells of fast-accurate subjects and slow-inaccurate subjects who have been studies much less often (Messer, 1975). From a clinical point of view, the two categories of maladaptive behavior are of greatest interest. It is important to recognize that both fast and slow responses may be associated with a high error rate and therefore may be maladaptive. For example, a child who requires an excessive amount of information and therefore has an extremely long and inefficient reaction time, may be an anxious child resulting in responses that are both slow and inaccurate. The impulsive and anxious child are similar not only in that they make more erroneous decisions, but also that they may both be excessively active (Kinsbourne, 1973). School teachers rated impulsive children as more hyperactive than reflective and fast-accurate children but similar in their hyperactivity to slow-accurate children (Ault et al, 1972). Since both fast and slow responses may be inaccurate, one may inquire whether response time is in fact a sensitive index of the child's tendency to evaluate his hypotheses carefully. An impulsive child may look at the MFF display, and, externally-governed by the response, may prematurely point to his guess without sufficient information, resulting in short latencies and many errors. However, another child may initially

attend to the task but then be distracted by some unrelated, internally governed activity before responding, resulting in longer latencies but high error rates. The former child may be described as impulsive, while the latter child may be described as distractible. Although impulsive and anxious or distractible children may be similarly maladaptively active, Kinsbourne (1977) has suggested that there are qualitative differences in their activity with the anxious child engaged in rigid, repetitive "displacement" activity that is not directed towards any goal and the similarly overactive impulsive child being involved in uninhibited and premature movement towards a series of goals.

Excess levels of activity have been thought to be the most striking symptom of hyperactivity (Laufer, 1957). Consequently, most studies of hyperactivity have selected children for inclusion in the experimental group on the basis of chronic, severe, and sustained hyperactivity (e.g. Weiss, 1968; Eisenberg, 1966; Werry and Sprague, 1974). It can be expected then that a group of children diagnosed as hyperactive on the basis of that criterion would include both anxious and impulsive children. Since the manifestation of extreme motility can be the final common pathway of two distinctly different pathological processes, the response of these two types of excessively active children to psychoactive drugs may be quite different. Impulsive children may be helped by stimulant medication while anxious children may be hindered by stimulants but facilated by tranquilizers (Kinsbourne, 1977). When this heterogenous group of children diagnosed as hyperactive on the basis of surface observations of excess motility are given a trial of

stimulant medication, many fail to respond favorably (Satterfield, 1974; Wender, 1971). In any study of drug responsiveness of hyperactive children, provision must be made to identify the significant minority of behaviorally hyperactive children who respond adversely to stimulants. It is generally acknowledged that about 30% of all children referred with symptoms of hyperactivity have an adverse rather than a favorable response to stimulants (Eisenberg, 1971; Wender, 1971; Safer & Allen, 1975).

Not only is the use of excess activity levels as the single most important diagnostic sign of hyperactivity inefficient because it includes children who are active as a result of opposing pathologies, but also because it excludes those hypoactive children who have been shown to respond favorably to stimulant medication. Bradley and Bowen (1941) demonstrated that stimulants resulted in increased energy, affect, and alertness, and improved initiative and interest in the surrounding in a group of children who were originally shy, withdrawn and underactive. Bender (1949), and Wender (1971) among others, also noted in clinical practice that there was a group of hypoactive children whose performance was facilitated by stimulants. A number of children initially referred to the Learning Clinic at the Hospital for Sick Children for lack of success in school who were described as quiet, shy, and daydreamy, were found to have problems focusing and maintaining attention. When given a trial of Ritalin in the Clinic, their performance on a number of tasks improved. Subsequent reports from both the teachers and parents supported these results. In the present study we specifically included hypoactive and distractible children to determine the effect of stimulant drugs on their cognitive style.

We have recently demonstrated that methylphenidate results in improvement on a variety of performance and behavior measures after the administration of one initial pill and that with a subsequent substitution of a placebo pill, the subjects revert to their old behavior (Kinsbourne, 1975; Swanson & Kinsbourne, 1976). The fact that children do respond to an acute administration of the drug makes it possible to determine which children respond favorably to the drug and which respond adversely. This procedure removes the need for long-term drug trials which can be harmful to the adverse responders and the need for reliance on the subjective measures of observation and questionnaires. Taking advantage of the quick acting effect of the drug methylphenidate (which when taken orally starts within a half an hour and lasts for four hours) makes it possible within a single day to quantify changes in behavior by appropriate laboratory tests on drug and on placebo.

In the present study, the paired associate learning task described elsewhere (Swanson & Kinsbourne, 1976; Swanson et al, 1977) was used to identify and separate the adverse responders from the favorable responders to stimulant treatment. This separation was in addition to the classification of impulsive or distractible symptom types.

Thus, three groups of subjects were defined: adverse responders, favorable-impulsive responders, and favorable-distractible responders. The basic question of this study was this: How is cognitive style (as inferred from MFF performance) affected by stimulant medication?

## METHOD

Subjects: The subjects were initially referred to the Learning Clinic at the Hospital for Sick Children for hyperactivity and/or learning problems and were found on the basis of a pediatric examination and medical history, a psychological evaluation, and a school report to have attention problems that were significantly impairing their behavior and school progress. Only those children who demonstrated that stimulant medication facilitated their performance on a paired-associate learning task (Swanson & Kinsbourne, 1976), a mother-child cooperative task (Humphries et al, 1977), and an avoidance conditioning task (Freeman, 1977) and who subsequently showed improvement in both behavior and performance at home and at school, were included in the favorable responder category. Others were described as non-responders or adverse responders. Data is reported for the latter group for comparison purposes. There were 55 subjects in all: 29 were categorized on the basis of pre-testing as favorable responders (25 male, 4 female; mean age 8.9) and 26 as adverse responders (21 male, 5 female; mean age 8.11). Subjects ranged in age from 7 years 0 months to 15 years 9 months.

The drug responsive subject presented as two distinct clinical groups. On the basis of teacher referrals, parent profiles, school records, medical histories, and a pediatric consultation, it was determined that 19 subjects (16 male, 3 female; mean age 8.10) could be described as impulsive, aggressive, acting out, while 10 subjects (9 male, 1 female; mean age 8.8) were referred for being distractible, daydreamy, or withdrawn. The experimenter remained blind as to the subjects' classification.

Procedure: Each subject was seen on two consecutive days. Medication, either drug or placebo, was administered at 8:30 a.m.; at 12:30 p.m. the opposite medication was given in a double-blind fashion. Each subject was

seen individually for a half hour in the morning and a half hour in the afternoon at the same time on both days. Pre-testing was conducted on Day 1 and the MFF given on Day 2. Drug states remained unknown to both E and S until all testing and scoring was complete.

Three forms of the MFF (preschool, child and adult) were administered in split-half fashion for a.m. and p.m. Six items from each form were given at each session, resulting in two equivalent 18-item tests. The three forms were given in order of difficulty, both in terms of the number of alternatives to choose from (4, 6, or 8) and also the subtlety of differences in the visual cues. That is, the adult 8-alternative form contained the greatest amount of response uncertainty. The standard MFF instructions were read (see Kagan et al, 1964) and the subject was reminded to "look at the standard figure and find the figure that is exactly the same. There is only one that is the same. You can take as long as you want or answer as quickly as you want". The reaction time to the first response (latency) and the number of trials to the correct response (errors) were recorded for each item.

## RESULTS AND DISCUSSION

For purposes of the present paper a summary of the findings will be presented. More detailed analyses will be reported elsewhere (Mock, Swanson, and Kinsbourne, 1978).

Figure 1 depicts in histogram form the MFF latency and error results for all favorable and adverse responders in placebo and drug conditions

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Insert Figures 1 and 2 about here

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FIGURE 1

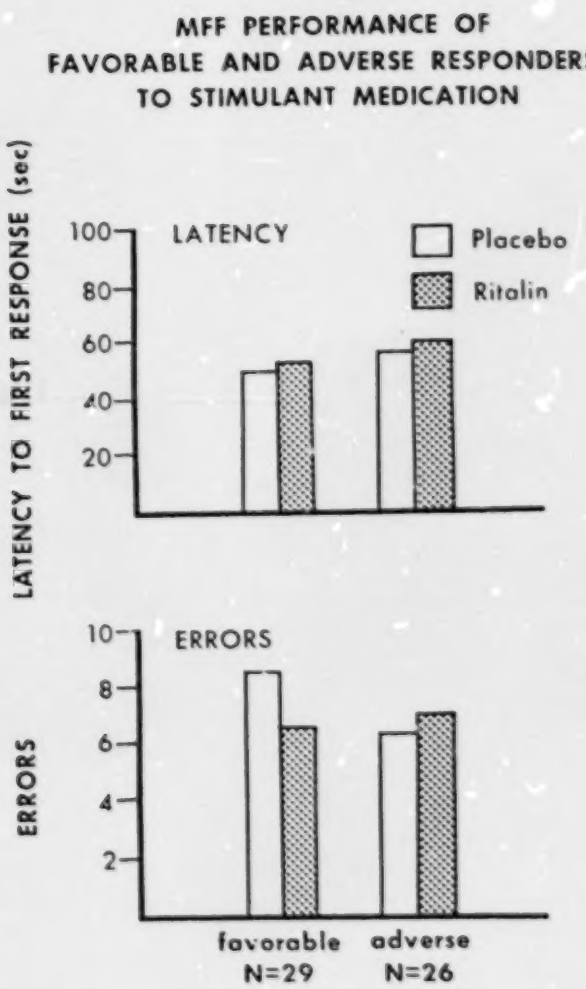
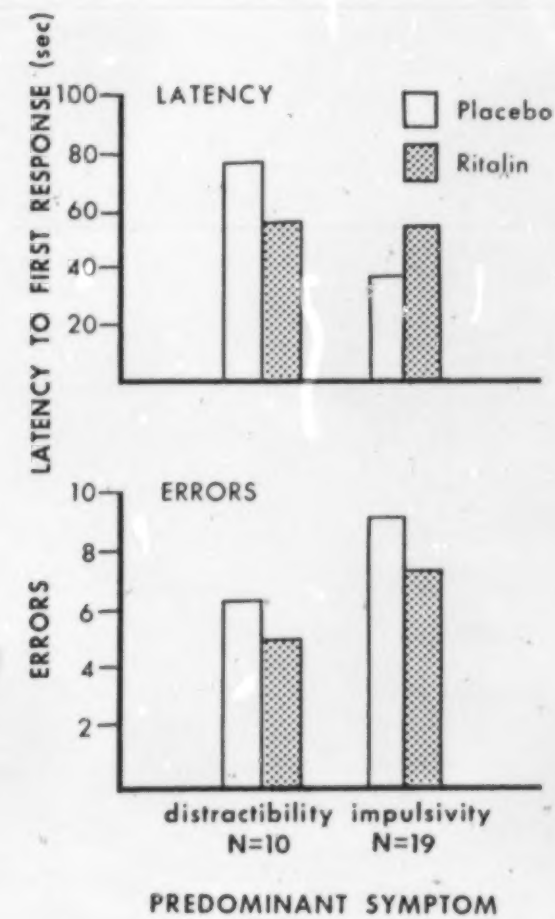

MFF PERFORMANCE OF
FAVORABLE AND ADVERSE RESPONDERS
TO STIMULANT MEDICATION
LATENCY TO FIRST RESPONSE (sec)
100
80
60
40
20
LATENCY
Placebo
Ritalin
ERRORS
10
8
6
4
2
ERRORS
favorable
N=29
adverse
N=26

FIGURE 2

MFF PERFORMANCE FOR TWO GROUPS
OF FAVORABLE RESPONDERS
CLASSIFIED IN TERMS OF SYMPTOM TYPE



(drug responsiveness having been determined by a paired associate learning test, Swanson and Kinsbourne, 1976). It is evident in Figure 1 that there is very little difference in the latency of favorable responders on and off the drug. Statistical analysis revealed no significant main effect of drug for favorable responders on the latency data. However, when the favorable responders are categorized according to their clinical profile as distractible and impulsive (Figure 2), the reason behind the nonsignificant main effect becomes clear.

Subject type X drug interaction. Table 1 presents the means and standard deviations for the two dependent measures (latency and errors) investigated under placebo and drug conditions. Data is reported for three subject types (distractible responders, impulsive responders, and adverse responders). Since the standard deviations were proportional to the means, a log transformation was applied to the data before analyses of variance were performed. A univariate analysis of variance was carried out for each dependent variable.

While the main effects of subject type and drug state were not significant overall, the interaction of subject type X drug, which qualified the interpretation of main effects, was significant for latency ($F(2,52) = 7.46$, $p < .001$). That is, in the placebo condition, "distractible" subjects respond much more slowly (74.98 sec.) than "impulsive" subjects (36.36 sec.), while the effect of stimulant medication on the latency measure of MFF performance was to increase the time to decision taken by impulsive subjects (50.35) and to decrease the decision time taken by distractible subjects (51.99). The latency for adverse responders decreased slightly. Anecdotal evidence supports the notion that the so-called distractible subjects may be

spending a similar amount of on-task decision time as impulsives but may engage in unrelated activity before making an initial selection. Medication may normalize the amount of on-task behaviour for both groups. Further research is necessary and presently being conducted to determine if that is the mechanism involved.

Examination of the error data (Table 1, Figure 2) reveals that stimulant medication decreases the error rates of both groups of responders (from 6.3 and 9.4 to 4.8 and 7.6 respectively) but tends to increase slightly the errors of adverse responders, (from 6.3 to 6.8). The direction of these differences appears to be consistent across almost all subjects and for each level of the task. However, for the error data, neither the main effects of subject type and drug state nor the interactions were found to reach significance. This could be due to the fact that the tasks were applied to a very wide age-range, thereby increasing the error variance. In further research the task is calibrated and an examination of the age-appropriate items included in the analyses (Mock, Swanson, and Kinsbourne, 1978). Pilot work on a more restricted age-range revealed significant trends in the error data in the described directions (Mock, 1976), while a further investigation including related cognitive tasks and a case study analysis also supports these findings (Mock, Bell, and Herman, 1978).

With regard to the question of the influence of a stimulant drug on cognitive style (as measured by the MFF), these findings suggest that the effect of medication on the latency of response may depend on the type of patient: the drug induces the impulsive patients to slow down, and the

TABLE 1

MEANS AND STANDARD DEVIATION FOR LATENCY AND ERRORS IN PLACEBO AND DRUG CONDITIONS

| | Latency | | | | Errors | | | |
|---|---|---|---|---|---|---|---|---|
| | Placebo | | Drug | | Placebo | | Drug | |
| | M | SD | M | SD | M | SD | M | SD |
| Distractible Responders | 74.98 | 43.00 | 51.99 | 25.10 | 6.3 | 3.5 | 4.8 | 3.3 |
| Impulsive Responders | 36.36 | 19.40 | 50.35 | 26.40 | 9.4 | 4.3 | 7.6 | 5.3 |
| Adverse Responders | 54.80 | 41.80 | 55.10 | 49.10 | 6.3 | 4.4 | 6.8 | 4.2 |

distractible patients to speed up. Therefore, the overall effect of the drug on MFF latency measures taken from a group consisting of both types of hyperactive children is essentially zero, with the interactive effect of subject type and drug state cancelling each other out. The population must be divided into two sub-groups (distractible and impulsive) before the drug effect can be predicted. In terms of errors score, both types of favorable responders tend to decrease errors on the MFF task in the Drug Condition relative to the Placebo Condition, and the patient who responds adversely in the Drug Condition on other laboratory tests also increases errors on the MFF task in the Drug Condition.

Thus, in an evaluated group of hyperactive children, unless they are separated according to whether their clinical history was chiefly of their impulsivity or distractibility, one measure of performance on the MFF task is apparently sensitive to drug effects (the error score), but the other is not (the latency score).

The implications of the present study are clear: the direction of the drug-induced effect on cognitive style is different for different types of patients even when they all ostensibly present the complaint of "hyperactivity" when referred to the Learning Clinic for assessment. The adverse response to stimulant medication occurs in over 30% of children assessed as being "hyperactive" on the basis of referral symptoms noted in a naturalistic environment (home, school) or by questionnaire. Using too much (or any) medication where it is inappropriate impairs the patient's cognitive functioning instead of improving it. This study reinforces this caution issued by

Bradley years ago (1937) and restated recently by Fish (1971). In terms of the criteria reviewed by Fish, the adverse responders may be the sub-group labeled "overanxious", while the favorable responders may be labeled "hyperkinetic" or "unsocialized aggressive" as well as "distractible". These impressions have not yet been systematically investigated but are currently being examined by assessing personality characteristics and symptom complaints which may differentiate favorable from adverse responders (Swanson, Roberts, Kinsbourne, 1977) as well as give further insights into individual differences in cognitive style and the effects of stimulant medication on cognitive style characteristics.

## SUMMARY AND CONCLUSIONS

The purpose of the study was to investigate whether methylphenidate (Ritalin) would differentially affect performance on Kagan's Matching Familiar Figures (MFF), a test of reflective/impulsive cognitive style. Fifty-five children who manifested behavioural symptoms of hyperactivity at home and in school and who had been referred to the Learning Clinic for a laboratory drug trial on stimulant medication were the subjects. They were given the split-half MFF task after having taken Ritalin and also after a placebo under double-blind conditions. Drug order and forms of the test were balanced and counter-balanced. For purposes of analysis, subjects were objectively classified on the basis of a standard laboratory test of learning ability as favorable or adverse responders to stimulant medication. The drug responsive subjects presented as two distinct sub-groups: those referred for aggressive and/or impulsive acting out behavior, and those

described by parents and teachers as daydreaming, withdrawn, and/or distractible with problems in focusing and maintaining attention. This information, (unknown to the experimenter until after data collection,) had been obtained through a detailed pediatric history, consultations with the parents, and examination of school records and teachers' appraisals.

For the adverse responders, MFF performance was poorer after stimulant medication than after placebo (i.e. more impulsive decision-making with increased errors). The drug treatment resulted in improved performance for both types of favorable responders. Specifically, the aggressive-impulsive sub-group increased decision time and decreased errors on Ritalin, while the withdrawn-distractible group improved performance by decreasing decision time and decreasing errors. Thus children who respond favorably to stimulants with regard to accuracy of performance, increase their response latency if it has been extremely short, but decrease it if it has been unduly long.

The results suggest that stimulant medication affects MFF performance differentially depending on the child's clinical/behavioral profile. The study has implications for the question of assessment techniques to determine the appropriateness or inappropriateness of stimulant therapy for children referred with symptoms of hyperactivity. The study also contributes to an understanding of the mechanisms of stimulant medication through its effects on children's cognitive style.

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